



# EMSP

Environmental Management Science Program

Project Summary Fact Sheet • August 1999



## CHEMICAL TREATMENT OF THE SATURATED ZONE

### IN-SITU REACTION OF CONTAMINANTS TO FORM SAFE PRODUCTS COULD GREATLY DECREASE THE TIME AND EXPENSE OF REMEDIATION

These projects are directed toward remediation of metals, radionuclides, and organic compounds in the groundwater. The emphasis is on in-situ methods to destroy, immobilize, remove, or stabilize contaminants and on other improvements to conventional pump-and-treat methods.

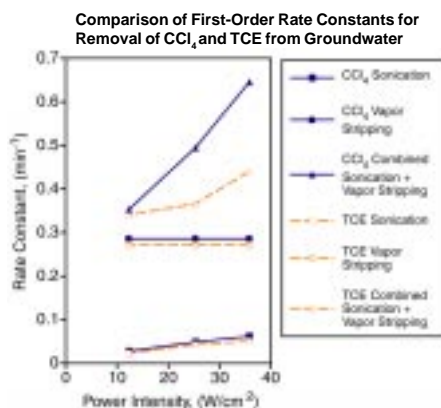
Technologies for in-situ oxidation of organic contaminants are already being demonstrated at Department of Energy (DOE) sites, and several EMSP projects are exploring the basic chemistry of related techniques:

- A palladium catalyst system is being used to expedite reactions with oxygen and carbon monoxide or hydrogen to form safe products from hazardous organic compounds.
- Ultrasonic irradiation has been found to result in sufficiently high temperatures in localized regions of water solutions to destroy many organic compounds. One EMSP project has developed techniques for measuring these temperatures for the first time, and another has investigated the detailed chemical mechanisms by which polychlorinated biphenyls (PCBs) are decomposed by ultrasonic irradiation.
- Down-well ultrasonic irradiation is being explored as a method to convert some difficult to treat compounds to more treatable forms.

Several separation techniques are also being explored:

- A new class of ceramic-supported polymer membranes is being made for removal of organics from water.
- The use of electric fields to improve separation efficiencies is being studied.

The use of surfactants for remediation is being demonstrated at a DOE site, and several EMSP projects are exploring basic science issues related to the technique. They include an investigation of a technique for studying what happens to injected surfactants, an experimental study that can compare various remediation strategies for dense nonaqueous phase liquids, and an investigation of surfactant combinations that can generate microbubbles for remediation processes in the subsurface.



#### Destruction of Organic Contaminants in Water

In-well ultrasonic irradiation may be useful in converting less tractable compounds into substances treatable by conventional technologies, as found by the Argonne National Laboratory and coworkers team.

### PROBLEMS/SOLUTIONS

- Plumes from DOE sites have contaminated more than 600 billion gallons of groundwater, and remediation efforts at some sites are projected to continue for many decades. Basic science studies of new remediation technologies can still have a significant impact on cost savings in the future.
- Conventional separations, such as distillations, are too expensive for removal of low concentrations of organic compounds from water. New polymer membranes have been synthesized by an EMSP project, and they may be applicable to large-scale separations of organic compounds from water by pervaporation techniques.
- New methods for destruction of organic contaminants must not require the introduction of new hazardous materials into the environment. Ultrasonic irradiation is being explored as an inexpensive technique that can destroy most organic compounds in water at a low cost, relative to conventional pyrolysis.
- Surfactant enhanced aquifer remediation is already being demonstrated in Idaho. Several EMSP projects are exploring basic science issues necessary for understanding the optimal use of this technique.

### ANTICIPATED IMPACT

- Each gallon of an organic contaminant that is destroyed in-situ can reduce the volume of water that must be extracted for surface treatment by as much as 300 million gallons.
- Dense nonaqueous phase liquid contamination exists at every major DOE site. For example, a carbon tetrachloride plume in the groundwater under the 200 West area at Hanford will require up to 56 years to remediate by current pump-and-treat methods. Effective in-situ remediation could decrease the remediation time by decades.
- The United States is a leader in the production of equipment for ultrasonic irradiation, and applications for groundwater remediation could make this an even more vital industry.

## Destruction of Organic Contaminants in Water

The Pennsylvania State University group investigated the chemistry of reactions of oxygen with a variety of organic compounds dissolved in water. They have found that metallic palladium as the catalyst along with carbon monoxide and/or hydrogen can be used to completely oxidize a wide variety of common organic pollutants. Chlorinated organics could be converted to safe products using NO<sub>x</sub>-mediated oxidation.

The use of ultrasonic irradiation to destroy polychlorinated biphenyls (PCBs) in water has been investigated by a group at Purdue University, and they have explored the detailed chemical processes that accompany this simple technique. They have discovered some of the parameters that affect optimal destruction of PCBs as well as several common pesticides in water.

Fundamental aspects of ultrasonic irradiation have also been investigated by the University of Illinois team, and they have been able to measure the extraordinarily high temperatures achieved in microbubbles within an otherwise cool liquid. They have also shown that turbulent flows of fluid are somewhat less efficient in inducing localized high temperatures with subsequent organic compound decomposition. The objective is to understand the requirements for large-scale treatment of contaminated water.

Vapor stripping and biodegradation are techniques that are already being used for removal of volatile organic compounds from the subsurface, but many common contaminants are either insufficiently volatile or not subject to biodegradation. The Argonne National Laboratory/California Institute of Technology/Stanford University team has found that in-well ultrasonic irradiation may be useful in converting these more intractable compounds into substances treatable by conventional technologies.

## Separation of Pollutants from Water

The University of California – Los Angeles group has synthesized thin polymer membranes on a ceramic support for pervaporation removal of a variety of organic pollutants from water. The contaminated water is passed through a tubular ceramic-supported polymer (CSP) system, and a vacuum is applied to the outer side of the CSP. The polymer is constructed to be more permeable to the organic compounds than it is to water, and the system has been demonstrated to be a very promising method for large-scale treatment of contaminated water.

The objective of the Oak Ridge National Laboratory/University of Tennessee project is to explore the use of electric fields to improve separation efficiencies of processes such as solvent extraction, distillation, and vapor stripping. The team has studied the effects of electric fields on vapor-liquid, liquid-liquid, and solid-liquid equilibria. The use of electric fields with electrodes made of carbon aerogel is also being investigated for the removal of metal ions.

## Surfactant Enhanced Recovery of Contaminants

Surfactants mixed with water can solubilize and mobilize dense nonaqueous phase liquids (DNAPLs) in the subsurface, and the Oregon State University group has developed a “push-pull” technique for studying the fate and transport of injected surfactants using a single well. Quantitative information on surfactant sorption or residual DNAPL solubilization potential can be obtained in only one day of field work at most sites.

The principal objective of the Sandia National Laboratory project has been the construction of both experimental and computational models for DNAPL migration within heterogeneous porous media. The experimental system has also been used to conduct laboratory experiments that can compare DNAPL remediation strategies, and the first technique to be investigated was surfactant mobilization and solubilization.

An objective of the Lawrence Berkeley National Laboratory project is to develop a quantitative understanding of interactions between contaminants and gas-water interfaces, and the group has developed an experimental technique for determining partitioning of surface-active colloids at air-water interfaces. Another goal is to explore the use of surfactant stabilized microbubbles for in-situ remediation, and the group has investigated surfactant combinations that generate microbubbles that are stable at sufficiently high pressures to be used in the subsurface.

## PROJECT TEAMS

### (EMSP AWARD NUMBER)

- Pennsylvania State University (54122)
- Purdue University (54834)
- University of California – Los Angeles (54926)
- Oak Ridge National Laboratory  
University of Tennessee (55119)
- Oregon State University (55196)
- University of Illinois (55211)
- Argonne National Laboratory  
California Institute of Technology  
Stanford University (55374)
- Sandia National Laboratory (55395)
- Lawrence Berkeley National Laboratory (55396)



FOR ADDITIONAL INFORMATION ABOUT THE EMSP, PLEASE CONTACT ONE OF THESE REPRESENTATIVES:

Mark A. Gilbertson  
Director, Office of Science & Risk  
(202) 586-7150  
!emsp@id.doe.gov  
www.em.doe.gov/science

Tom Williams  
EMSP Director, DOE-ID  
(208) 526-2460  
!emsp@id.doe.gov  
www.id.doe.gov/emsystems/emsp

Roland Hirsch  
EMSP Director, Office of Science  
(301) 903-9009  
!emsp@id.doe.gov  
www.er.doe.gov